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TECHNICAL REPORT

DoD Resource Augmentation for Civilian Consequence Management (DRACCM) Tool

July 2015

DTRA01-03-D-0014

Jason Rodriguez et al.

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14. ABSTRACT
The goal of this effort was to develop a tool that is capable of assessing the effect of CBRN exposures on civilian populations and medical infrastructure in order to inform DoD planners at the NORTHCOM/Joint Task Force (JTF) level what additional resources might be required to support civilian authorities. DRACCM allows planners to import exposures, calculate time-dependent casualties, and to assess the beneficial effect of medical countermeasures including the negative effect of non-ideal or late treatment.

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CONVERSION TABLE

Conversion Factors for U.S. Customary to metric (SI) units of measurement.

MULTIPLY ⟶ BY ⟶ TO GET

TO GET ⟵ BY ⟵ DIVIDE

angstrom	1.000 000 x E -10	meters (m)
atmosphere (normal)	1.013 25 x E +2	kilo pascal (kPa)
bar	1.000 000 x E +2	kilo pascal (kPa)
barn	1.000 000 x E -28	meter^2 (m^2)
British thermal unit (thermochemical)	1.054 350 x E +3	joule (J)
calorie (thermochemical)	4.184 000	joule (J)
cal (thermochemical/cm^2)	4.184 000 x E -2	mega joule/m^2 (MJ/m^2)
curie	3.700 000 x E +1	*giga bacquerel (GBq)
degree (angle)	1.745 329 x E -2	radian (rad)
degree Fahrenheit	$t_k = (t^o f + 459.67)/1.8$	degree kelvin (K)
electron volt	1.602 19 x E -19	joule (J)
erg	1.000 000 x E -7	joule (J)
erg/second	1.000 000 x E -7	watt (W)
foot	3.048 000 x E -1	meter (m)
foot-pound-force	1.355 818	joule (J)
gallon (U.S. liquid)	3.785 412 x E -3	meter^3 (m^3)
inch	2.540 000 x E -2	meter (m)
jerk	1.000 000 x E +9	joule (J)
joule/kilogram (J/kg) radiation dose absorbed	1.000 000	Gray (Gy)
kilotons	4.183	terajoules
kip (1000 lbf)	4.448 222 x E +3	newton (N)
kip/inch^2 (ksi)	6.894 757 x E +3	kilo pascal (kPa)
ktap	1.000 000 x E +2	newton-second/m^2 (N-s/m^2)
micron	1.000 000 x E -6	meter (m)
mil	2.540 000 x E -5	meter (m)
mile (international)	1.609 344 x E +3	meter (m)
ounce	2.834 952 x E -2	kilogram (kg)
pound-force (lbs avoirdupois)	4.448 222	newton (N)
pound-force inch	1.129 848 x E -1	newton-meter (N-m)
pound-force/inch	1.751 268 x E +2	newton/meter (N/m)
pound-force/foot^2	4.788 026 x E -2	kilo pascal (kPa)
pound-force/inch^2 (psi)	6.894 757	kilo pascal (kPa)
pound-mass (lbm avoirdupois)	4.535 924 x E -1	kilogram (kg)
pound-mass-foot^2 (moment of inertia)	4.214 011 x E -2	kilogram-meter^2 (kg-m^2)
pound-mass/foot^3	1.601 846 x E +1	kilogram-meter^3 (kg/m^3)
rad (radiation dose absorbed)	1.000 000 x E -2	**Gray (Gy)
roentgen	2.579 760 x E -4	coulomb/kilogram (C/kg)
shake	1.000 000 x E -8	second (s)
slug	1.459 390 x E +1	kilogram (kg)
torr (mm Hg, 0^0 C)	1.333 22 x E -1	kilo pascal (kPa)

*The bacquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.

**The Gray (GY) is the SI unit of absorbed radiation.

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PREFACE

The research work described in this report was conducted for the Defense Threat Reduction Agency (DTRA) under contract number DTRA 01-03-D-0014-0030. The authors would like to thank Ms. Stephanie Hamilton, Ms. Nancy Nurthen, Dr. Chris Kiley, and Mr. Rick Fry of DTRA's Information Systems Capability Development Office (J9CBI) for their leadership and management of the Health and Human Effects Modeling for CBRN program during this contract.

The authors would especially like to recognize and thank Dr. Alan Moloff, COL U.S. Army Ret., for his contributions to their understanding of the mechanisms for Department of Defense (DoD) medical support of civilian authorities.

SUMMARY

This report documents the models and datasets used within the Department of Defense (DoD) Resource Augmentation for Civilian Consequence Management (DRACCM) tool. DRACCM was developed for the Defense Threat Reduction Agency (DTRA) by Applied Research Associates, Inc. (ARA) to aid planners at the Northern Command (NORTHCOM)/Joint Task Force (JTF) level in assessing local, state, and non-DoD Federal medical resource shortfalls for chemical, biological, radiological, and nuclear (CBRN) attacks on civilian populations so that the DoD can effectively make plans to fill civilian gaps in medical materiel and personnel resources. This document gives a brief history of DRACCM development before going into detail for individual models and datasets as well as an example scenario that can be studied with DRACCM.

1.0 INTRODUCTION

In the event of a CBRN incident, a toxic industrial chemical (TIC) release, or an influenza pandemic, the medical resource requirements necessary to successfully manage the civilian consequences can significantly exceed local, regional and state resources. In order to study the resource needs and shortfalls, ARA has worked with DTRA/J9CBI as well as the DTRA Reachback Center to develop the DoD Resource Augmentation for Civilian Consequence Management (DRACCM) tool that calculates patient streams for a number of civilian mass-casualty incidents in major cities, routes patients to the closest hospital, and estimates the ability of the hospitals to successfully treat the civilian casualties.

DRACCM has undergone several iterations that will be explained in this paper to establish its pedigree. The most recent version models resource requirements within CONUS, uses real hospital data, has an intuitive drag-and-drop interface, imports data from Reachback's modeling toolset for the spread of contagious disease called the Infectious Disease Analysis Capability (IDAC), which is a major component of the Comprehensive National Incident Management System (CNIMS) (Eubank, Barrett, Anil Kumar, & Marathe, 2004). In addition, DRACCM makes use of output from the Hazard Prediction & Assessment Capability (HPAC) and the Joint Effects Model (JEM), determines the requirements for beds, ventilators, doctors, and critical medical material, allows planners to design custom population distributions for event planning, and allows planners to phase-in medical resource augmentation packages from state, non-DoD Federal, and DoD sources.

2.0 DRACCM HISTORY

DRACCM evolved from the methodology of the medical Nuclear, Biological and Chemical (NBC) Casualty & Resource Estimation Support Tool (NBC CREST) (U.S. Army Office of The Surgeon General, 2005), but with a different mission. DRACCM is designed for civilian incident management as opposed to NBC CREST's primary focus on deployed military populations. DRACCM had it roots with a quick calculator for avian influenza (strain H5N1) casualties and fatalities for large populations (Figure 2-1) developed for NORTHCOM pandemic training exercises supported by DTRA Reachback. The quick calculator allowed the user to specify the size of the population at risk and the number of initially infected persons in that population. It provided as output the estimated casualties and fatalities over time, leveraging the Allied Medical Publication-8 (B) (AMedP-8(B)) model of disease transmission for influenza which uses a time-dependent transmission function derived from the 1917 Camp Custer influenza outbreak (Bombardt & Brown, 2003) (Bloom & Rodriguez, June 2004). The output of the quick calculator is a Microsoft Excel spreadsheet with the desired data.

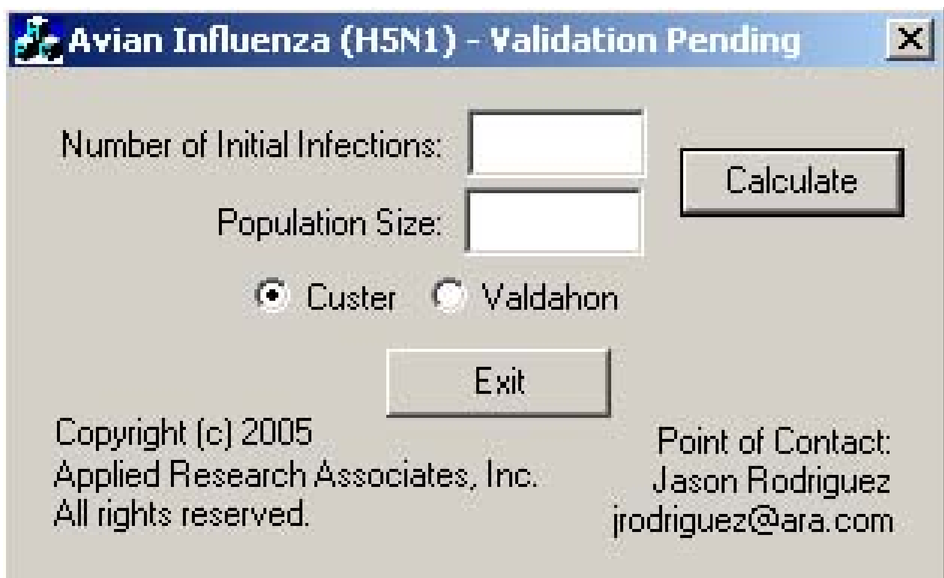

Figure 2-1. Avian Influenza quick calculator

The first version of our civilian medical resource estimation tool was called Civilian CREST 1.0 and was developed to support a NORTHCOM Ardent Sentry exercise in May 2006. Civilian CREST 1.0 had a Graphical User Interface (GUI) as illustrated in Figure 2-2 similar to that of NBC CREST. The GUI allowed a user to point-and-click hospitals and view the resources available vs. those required. There were eleven cities included in Civilian CREST 1.0: Atlanta, Austin, Baltimore, Chicago, Las Vegas, Los Angeles, New York City and its suburbs, Norfolk, St. Louis, San Francisco, Seattle, Tampa, Washington DC, and Southern California (Los Angeles to San Diego). Although Civilian CREST 1.0 had real hospital data with actual hospital locations for all of the cities, it did not have a routing algorithm that would send individuals to their closest hospital. Instead, infected individuals were evenly distributed among the city's hospitals.

Whereas this routing method is an acceptable approximation for influenza, it is not appropriate for overt chemical or biological releases or blast events, as the non-contaminated hospitals closest to the event would fill-up first.

Civilian CREST 1.0 made use of the H5N1 models implemented in the quick calculator described above. For medical resource estimation, the program used the algorithms from FluSurge, a basic model implemented by the Centers for Disease Control and Prevention (CDC) that allowed a user to define the average length of hospital stay for intermediate and severe injuries as well as the fraction of people who require extensive treatment.

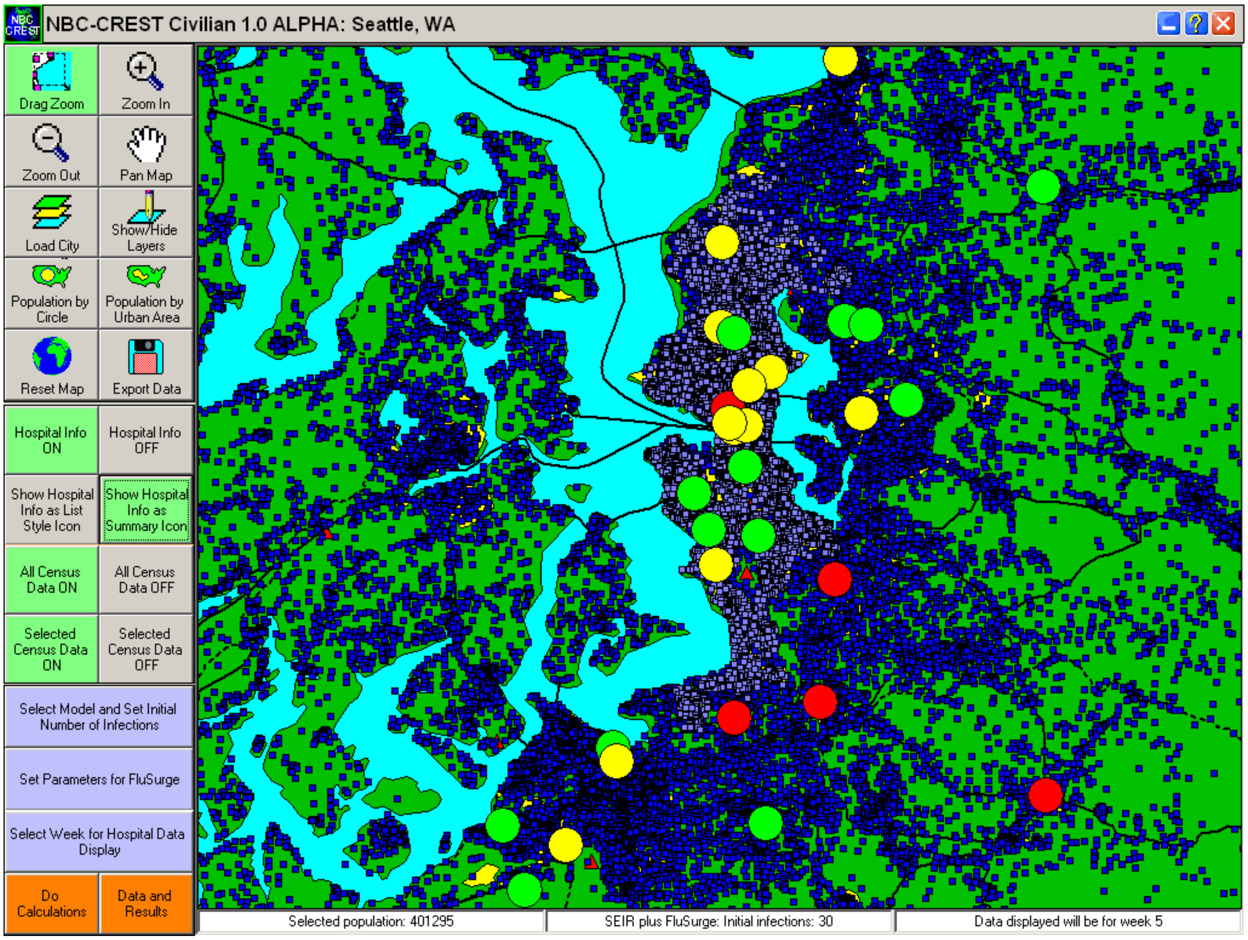

Figure 2-2. Civilian CREST 1.0 GUI supported NORTHCOM's Ardent Sentry exercise.

A year later, working with Reachback, ARA supported the Alabama National Guard's (ANG's) influenza epidemic training. The ANG wanted county-by-county casualty and medical resource requirement estimates. To meet this need, ARA rebuilt Civilian CREST with a C#-based intuitive interface and created Civilian CREST 2.0: Alabama (see Figure 2-3). We also implemented a routing algorithm to assign ill individuals grouped by census block to the nearest hospital. The color-coded areas in Figure 2-3 illustrate the catch basins for selected hospitals. We included a mechanism for importing patient datasets from the IDAC, DTRA's high-fidelity, agent-based contagious disease estimation tool.

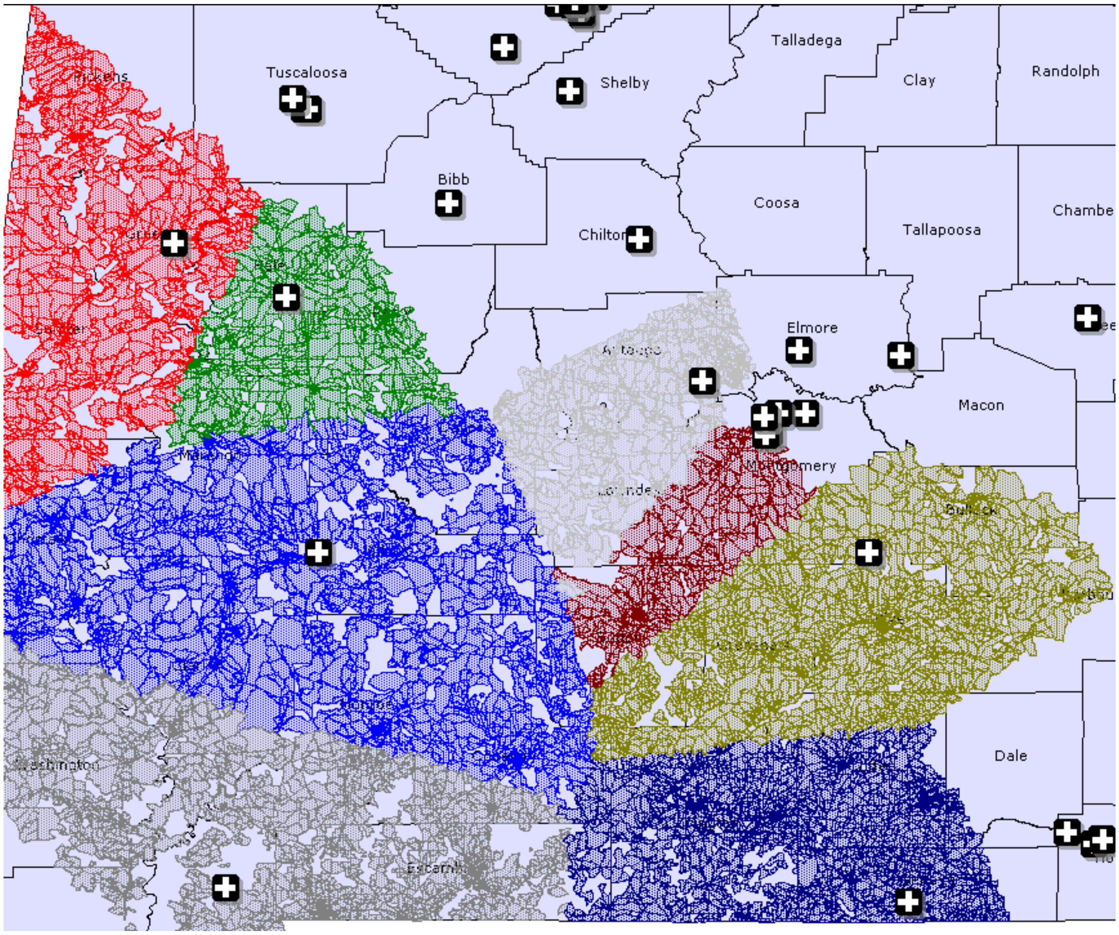

Figure 2-3. Screenshot from Civilian CREST 2.0: Alabama

The analysis done with Civilian CREST 2.0: Alabama proved the utility of this type of analytical tool and we were asked to develop a more robust version to support NORTHCOM's need for a contagious disease and medical support modeling tool. The result, Civilian CREST 2.0, is based on the 2.0: Alabama framework with several major additions. First, we included nine major cities and their outlying suburbs: Boston, Chicago, Dallas, Detroit, Los Angeles, Miami, New York City (see Figure 2-4), Seattle, and Washington DC. We also included an estimate of staff requirements and staffing availabilities for the nine regions. Finally, we added options to view IDAC data that had included school closings, vaccinations, antivirals, social distancing, no interventions, and a combination of all interventions as infection control measures.

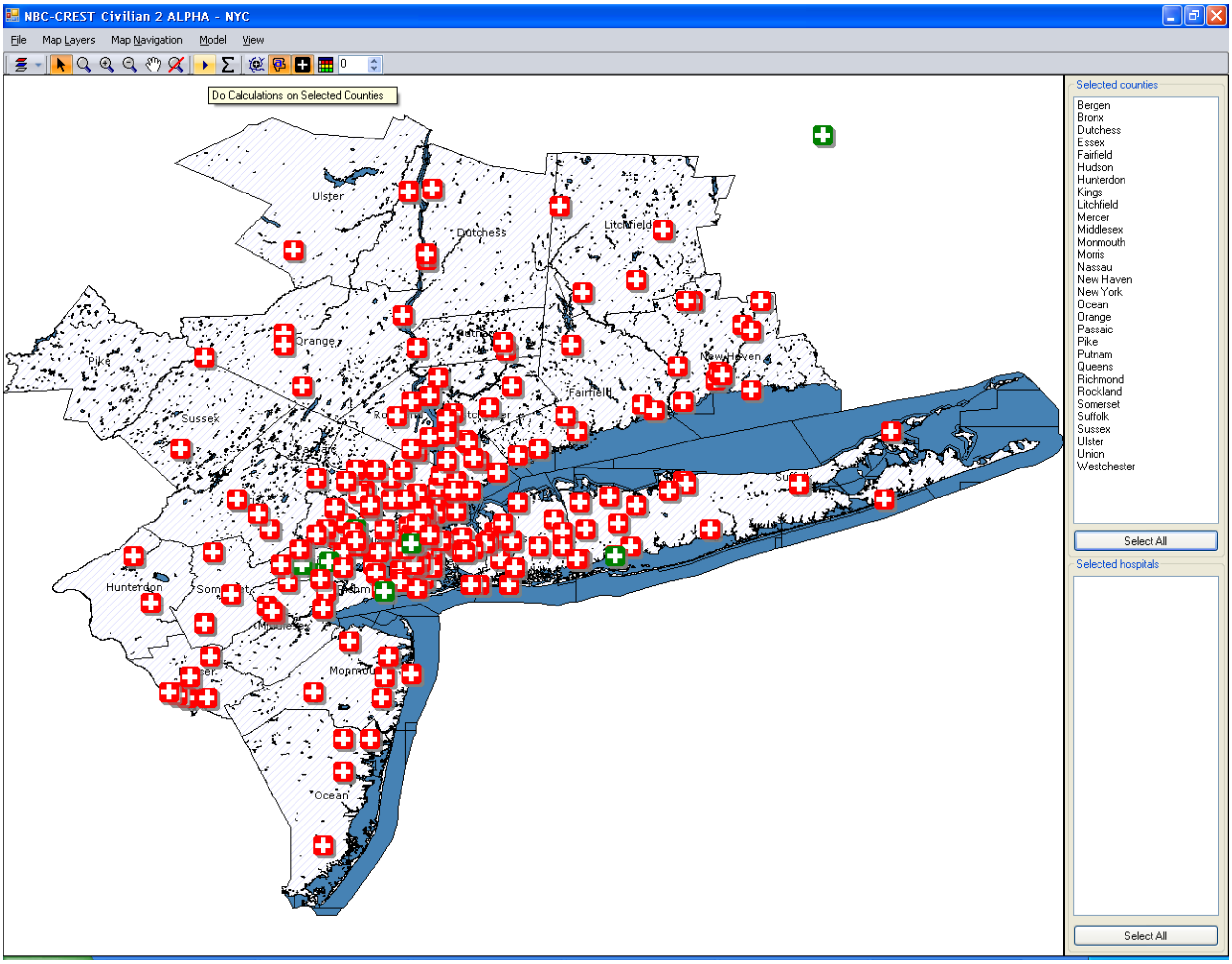

Figure 2-4. Civilian CREST 2.0 Screen Shot

Civilian CREST 2.0 was briefed to both DTRA and NORTHCOM as part of the CNIMS program and received a letter of commendation from NORTHCOM for the effort. This work led directly to the development of DRACCM, which is described in the following sections.

3.0 DRACCM COMPONENTS

DRACCM has several major improvements over Civilian CREST 2.0. These improvements include:

1. A web-based, ESRI map interface with an offline option
2. The ability to import exposure data from HPAC and JEM
3. Health effects models that underwent Independent Verification & Validation (IV&V) by the John Hopkins University (JHU) Applied Physics Lab (APL)
4. Critical medical resource requirement estimation
5. Effects of no or non-ideal treatment
6. Population builder for event planning
7. Hospital routing algorithms that are scenario dependent
8. The ability to time-phase medical resource augmentation packages

These components and more are discussed in the following subsections.

3.1 INTERFACE AND MAP

DRACCM uses freely available and distributable ESRI Geographic Information System (GIS) products for its main map interface as shown in Figure 3-1.

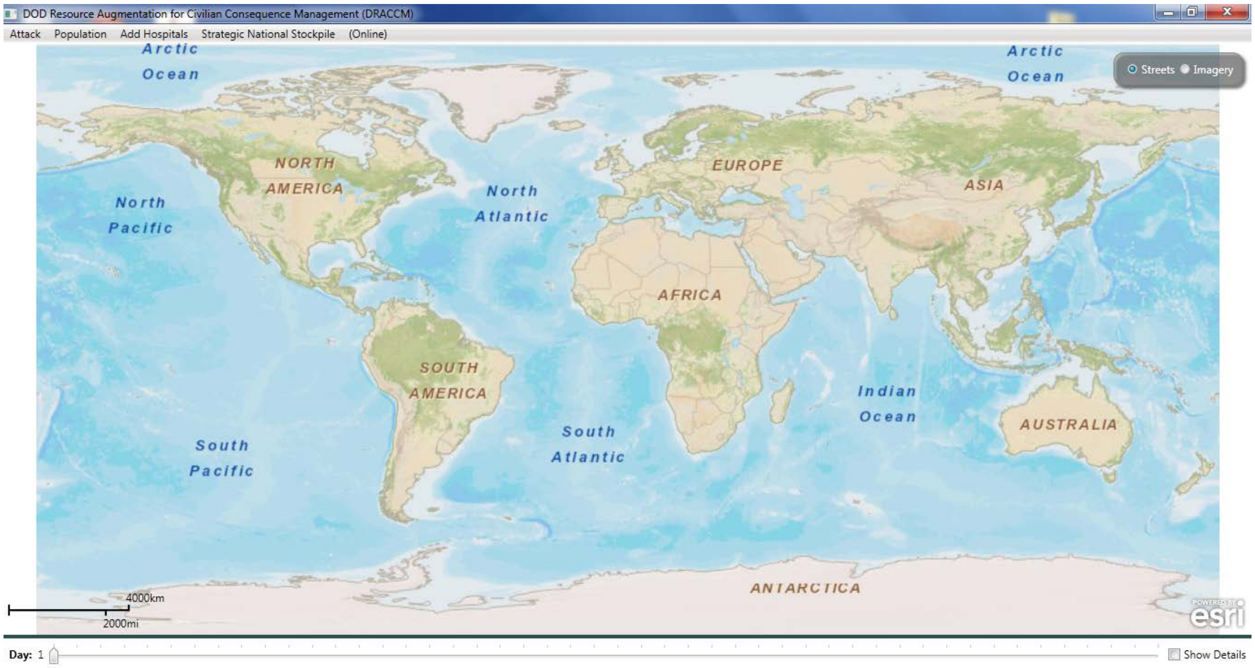

Figure 3-1. DRACCM GUI based on ESRI GIS products

The map has standard pan and zoom controls that allow you to see the details in an area of interest as illustrated in Figure 3-2.

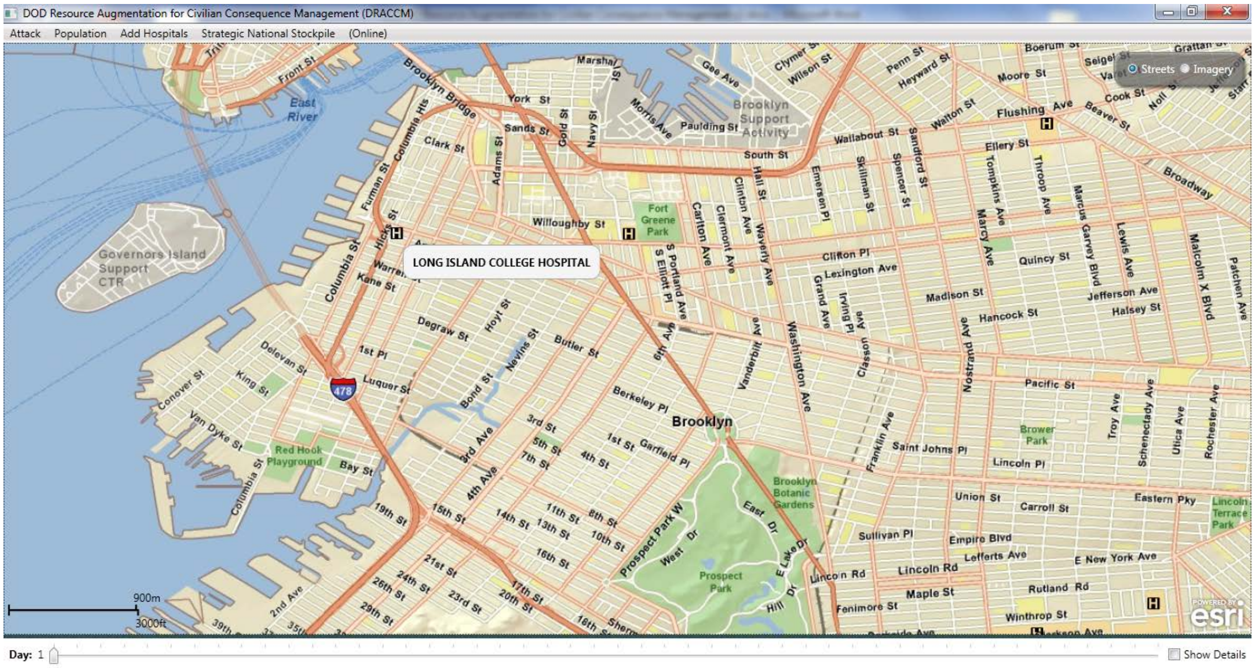

Figure 3-2. Detailed street view in DRACCM

DRACCM also allows the user to switch to satellite imagery as in Figure 3-3 if an internet connection is available.

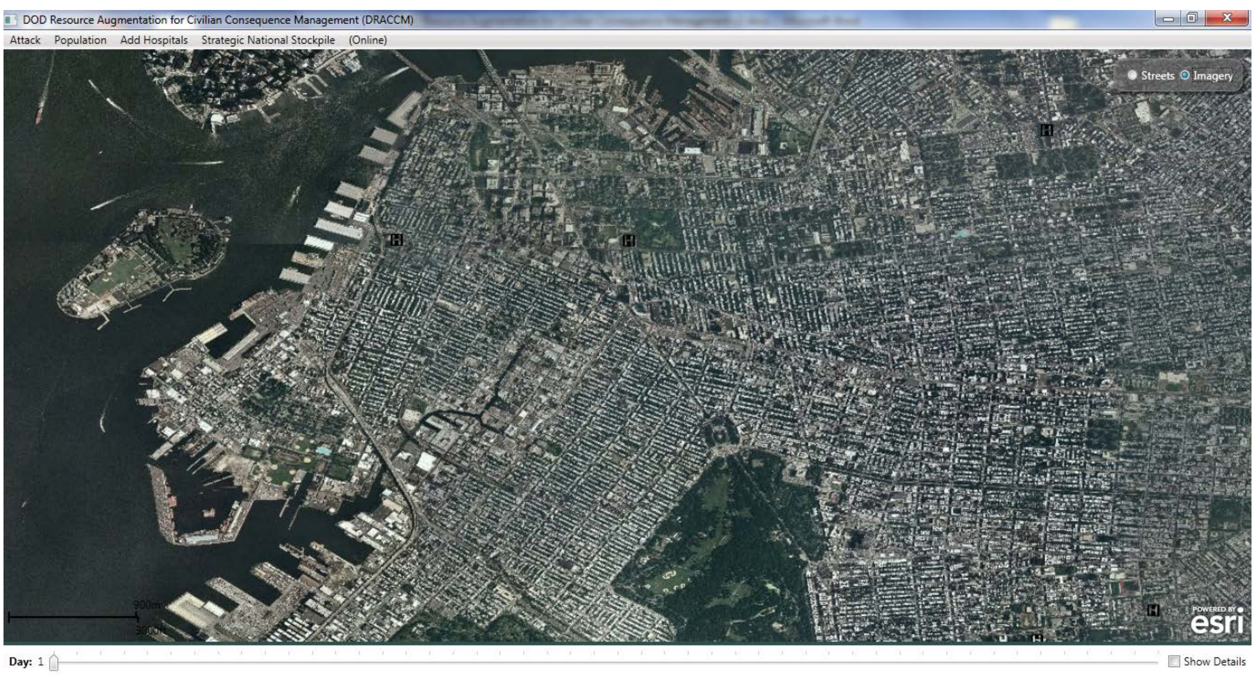

Figure 3-3. Satellite imagery in DRACCM

DRACCM functionality is controlled by either map clicks of by the menu bar shown in Figure 3-4. The menu bar allows the user to define the attack, population, civilian hospitals, or medical augmentation packages. These functionalities are described in the following subsections.

Figure 3-4. DRACCM menu bar

3.2 POPULATION

DRACCM makes use of several possible population sources. The default population comes from the TIGER/LINE shapefiles distributed by the United States Census bureau (Bureau, 2012). These shapefiles give population numbers and demographics by census block and are updated every year. DRACCM also has access to the day/night population database known as LandScan (Oak Ridge National Laboratory, 2012). These two databases each have their strengths and weaknesses. TIGER has better location fidelity, pinpointing individuals down to a single census block, good for assessing closest hospitals and the number of individuals exposed to a plume. LandScan has day/night population with lower location fidelity, giving the user the ability to assess the number and location of casualties in the morning and in the evening.

Another feature within DRACCM illustrated in Figure 3-5 is component for defining a custom population for event planning. This component allows a user to draw an area where the subpopulation will be located and define the number of individuals within that shape. The figure below shows a custom population (red polygon) in Central Park that has 250,000 people in it. This polygon may be analyzed separately or along with the normal civilian population.

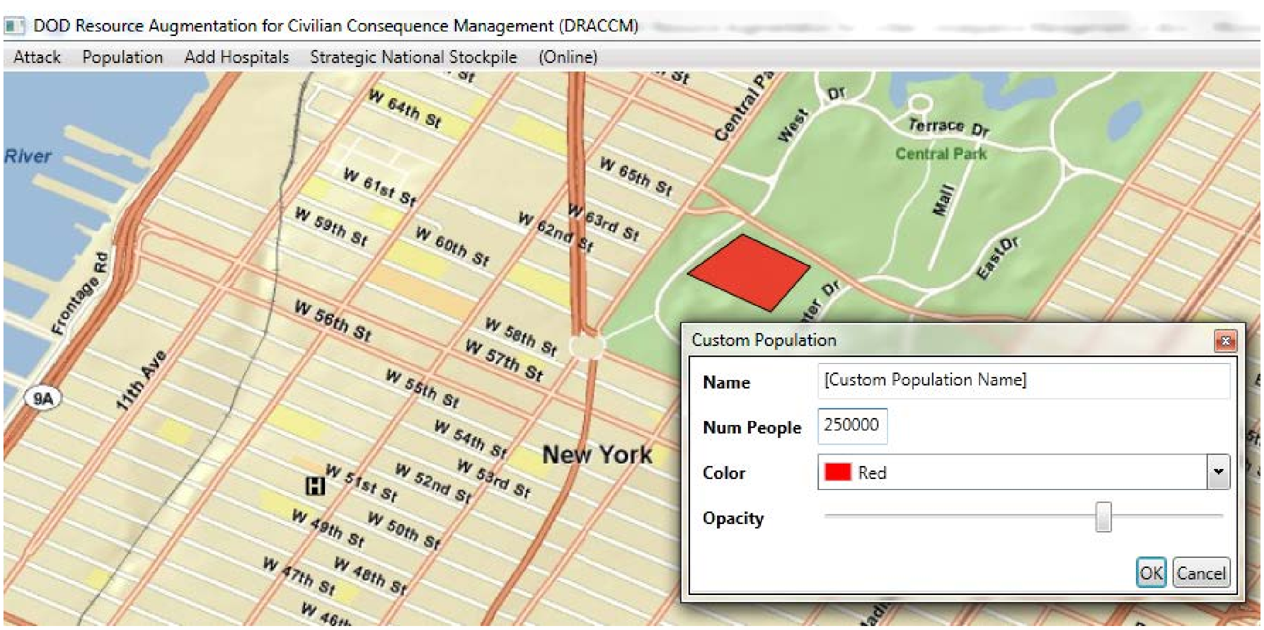

Figure 3-5. Custom population plotter in DRACCM

DRACCM can also be used to place a deployed military population within CONUS as in Figure 3-6 with an offensive unit placed on the map. The red icons represent an individual or a collocated group of individuals. There are currently 50 military unit templates within DRACCM representing various elements of the Army, Air Force, and Navy.

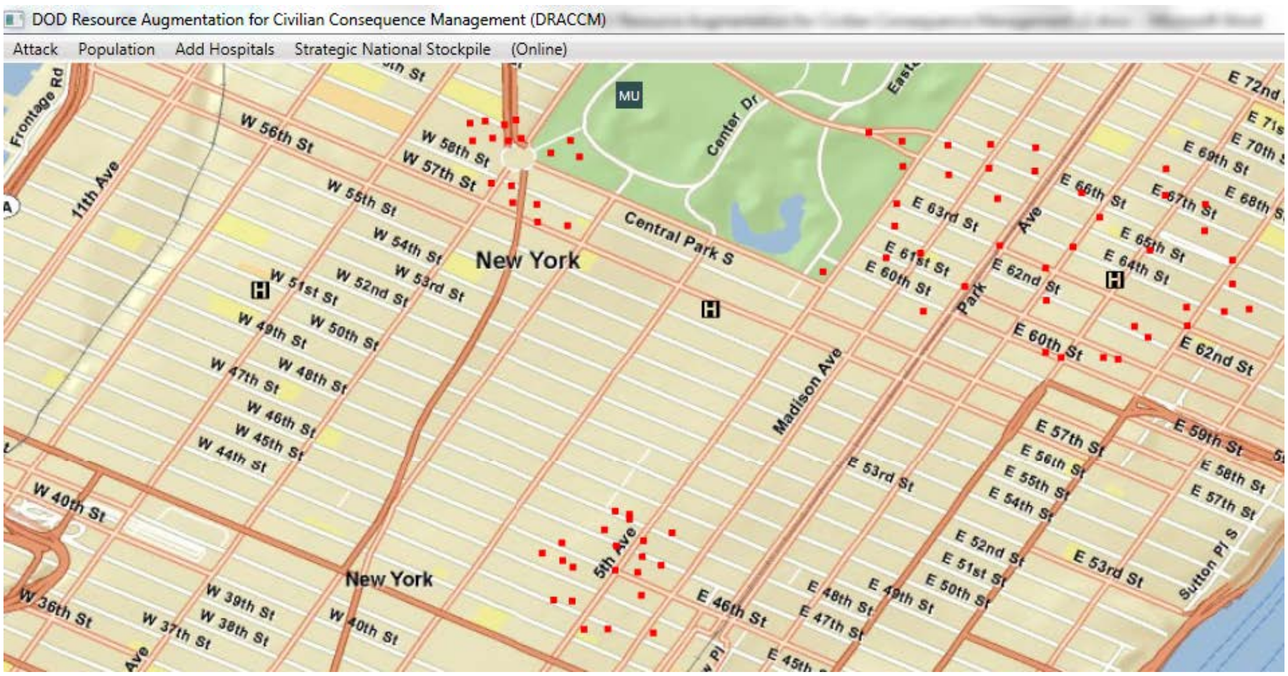

Figure 3-6. Military deployments may be represented in DRACCM

3.3 CBRN THREATS

DRACCM gives planners the ability to specify CBRN exposures using two different mechanisms. First, DRACCM allows the user to import a pre-calculated plume from HPAC or JEM as illustrated in Figure 3-7. The figure shows a smallpox plume from a large, aerial release with fixed wind in HPAC. Notice the red “x” marks under the plume. These are civilian hospitals that are considered contaminated as a result of the dispersion and whose resources will be removed from further analyses.

Figure 3-7. HPAC smallpox plume imported into DRACCM

The green “H” icons in Figure 3-7 are uncontaminated hospitals. The hospitals are color-coded with green meaning that there is enough critical medical resource at that hospital for a given day. An hospital icon coded yellow means that at least one critical medical resource is 90-100% allocated and red means that at least one critical medical resource is over 100% allocated. The GUI allows the user to view the hospital status on a day-by-day basis. There is more on this functionality in Section 3.5.

The second mechanism for specifying exposure allows the user as shown in Figure 3-8 to draw a contour on the map and specify the dose within that contour. This mechanism is good for detailed analysis of known, fixed exposures.

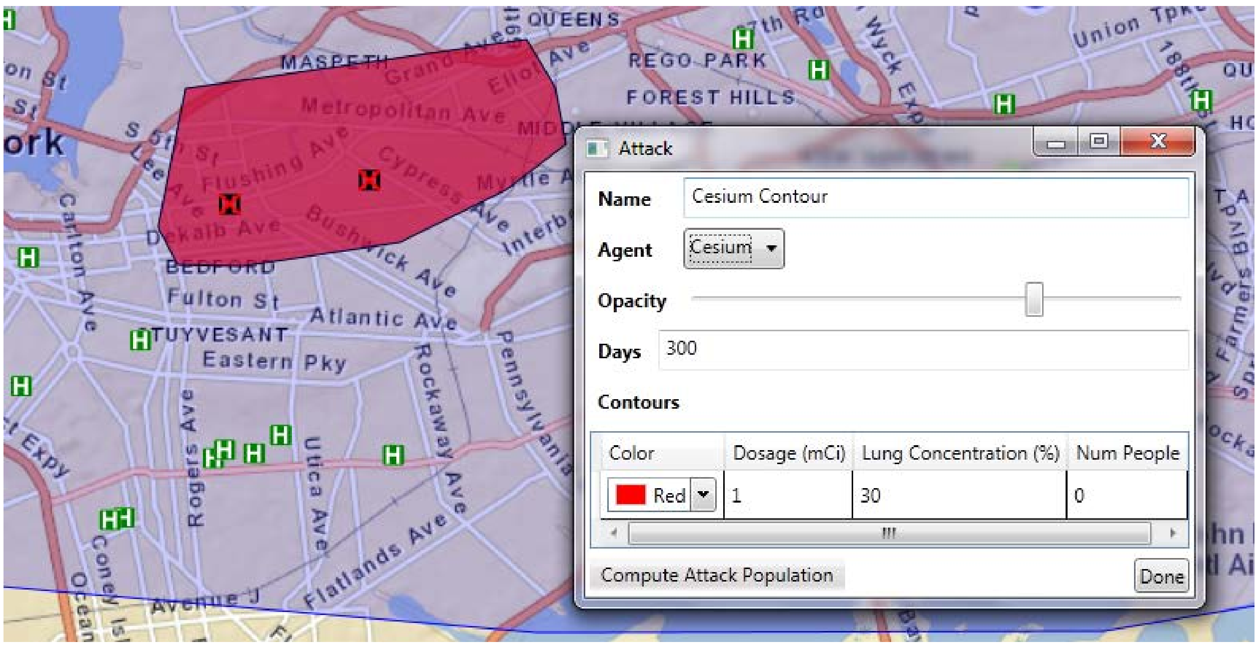

Figure 3-8. Custom attack contours in DRACCM

DRACCM currently has models for the following biological and chemical agents: tularemia, Q fever, SEB, anthrax, plague (with contagion), VEE, botulism, brucellosis, glanders, smallpox (with contagion), influenza, cesium, sarin, VX, and sulfur mustard. Additionally, DRACCM can calculate casualties resulting from the prompt radiation portion of a nuclear blast as well as releases of chlorine and phosgene.

3.4 HEALTH EFFECTS MODELS

DRACCM has the CBRN health effects models from NBC CREST that have undergone IV&V as noted above. These models accept dose and time-since-exposure and return an individual’s onset time, seek treatment time, litter time, and time to death or return to duty depending on the medical outcome. These models are described in detail in the NBC CREST technical manual (U.S. Army Office of The Surgeon General, 2005) and supporting documentation.

DRACCM also has access to three different contagious disease models: 1) CDC's FluSurge model which allows a user to define population size, attack rate, and epidemic duration and a Gaussian curve is fit to the data, 2) SEIR models as implemented for the Joint Effects Model (JEM) that estimate the population size and initial infections based on the area of interest and attack size and a set of difference equations driven by data derived from agent-based simulations and real-world outbreaks, and 3) imported data from DTRA's IDAC program. IDAC is an agent-based simulation that models the day-to-day interactions of individuals within a city using real city addresses, features, and demographics. IDAC runs on a super-computer located in DTRA's Albuquerque installation. DTRA's Reachback center ran Monte Carlo simulations of outbreaks within the cities under study and supplied the output data to ARA for inclusion in DRACCM.

Figure 3-9 shows IDAC data that allows the DRACCM user to study the effects of various infection countermeasures on the resource needs of city hospitals. Reachback supplied IDAC infection estimates for:

- No interventions
- School Closings; K-8 closings for the beginning of the epidemic
- Vaccinations; Pre-epidemic and pre-exposure vaccination
- Antivirals; Post-exposure medications
- Social Distancing; Individuals voluntarily keeping their distance from other individuals
- All Interventions; A combination of all of the above countermeasures

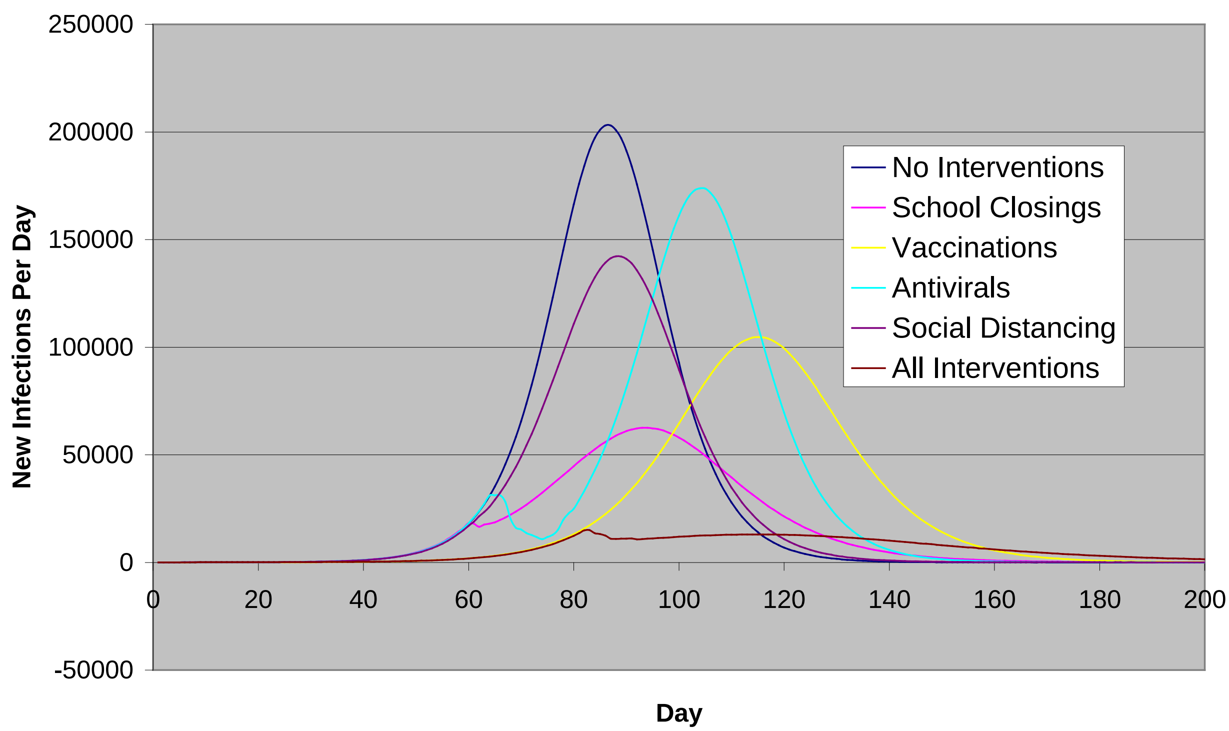

Figure 3-9. IDAC input for DRACCM assuming various infection controls against the spread of influenza in NYC and suburbs.

3.5 HOSPITALS AND MEDICAL RESOURCES

DRACCM uses a combination of hospital data obtained from the American Hospital Association and the HAZUS Database from the Federal Emergency Management Agency. For all CONUS hospitals, DRACCM has a database of available beds, ICU beds, and average occupancy rates. For select cities, DRACCM also has a database of ventilators and doctors. DRACCM also tracks critical material needs (such as oximes and atropine for organophosphate exposures or ciprofloxacin for anthrax).

DRACCM allows the user to incorporate hospitals into their analysis via several mechanisms. First, the use can select the hospitals that will be used in the analysis as shown in Figure 3-10. This mechanism is ideal in the event that a user wants to establish a hospital that's far away from the incident site as the spot to which serious casualties will be evacuated. This feature allows an incident in Washington DC with a hospital in Chicago included as part of the analysis.

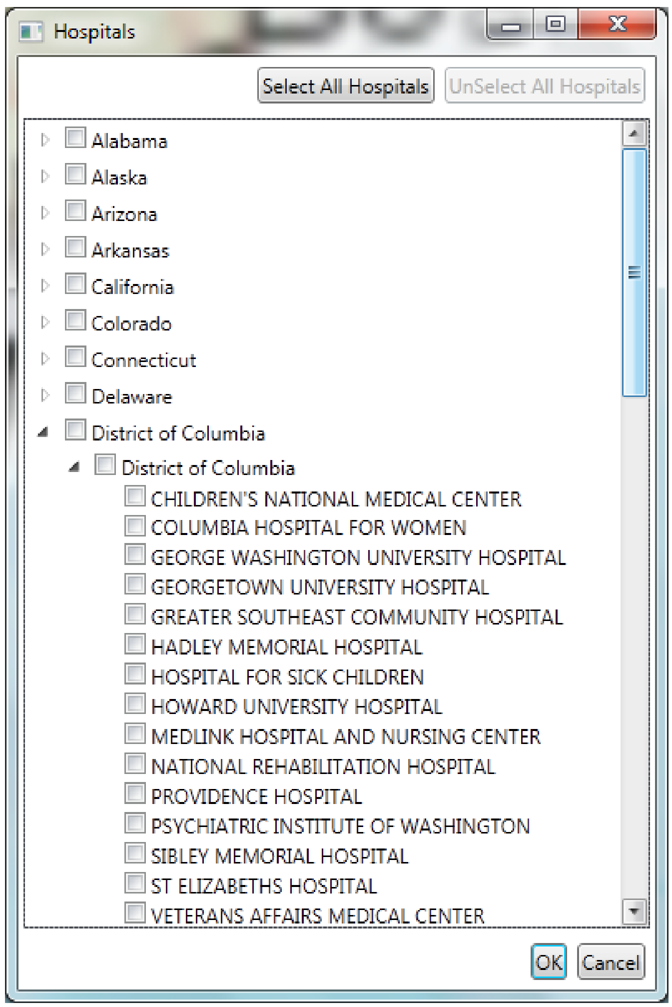

Figure 3-10. Hospital selection tool in DRACCM

Users can also draw an area of interest that becomes populated with all of the civilian hospitals within that area (see Figure 3-11). In the figure below, the majority of the hospitals in the New York City area were selected for analysis. They are the black "H" icons in the figure.

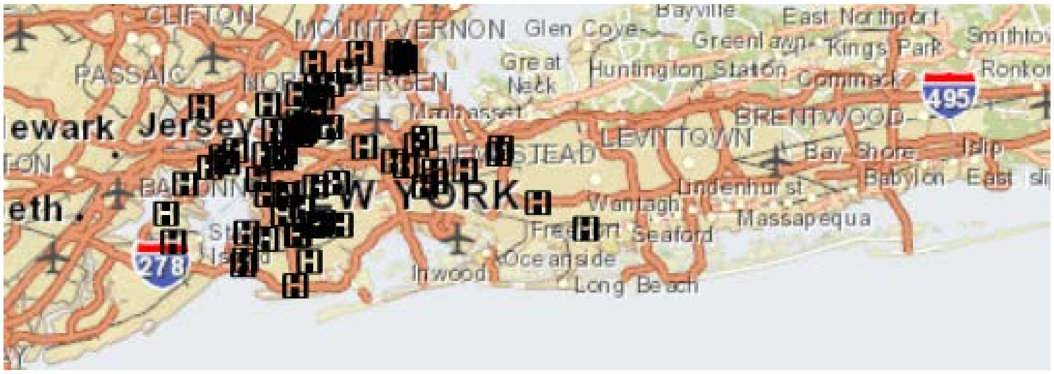

Figure 3-11. Hospitals within a user-specified area of interest

3.6 MEDICAL AUGMENTATION

DRACCM allows the user to augment the existing medical infrastructure in an area. Figure 3-12, Figure 3-13, and Figure 3-14 show three examples of medical augmentation; adding a quarantine center, an Air Force Expeditionary Medical Support (EMEDS) unit, and a Defense CBRN Response Force (DCRF), respectively.

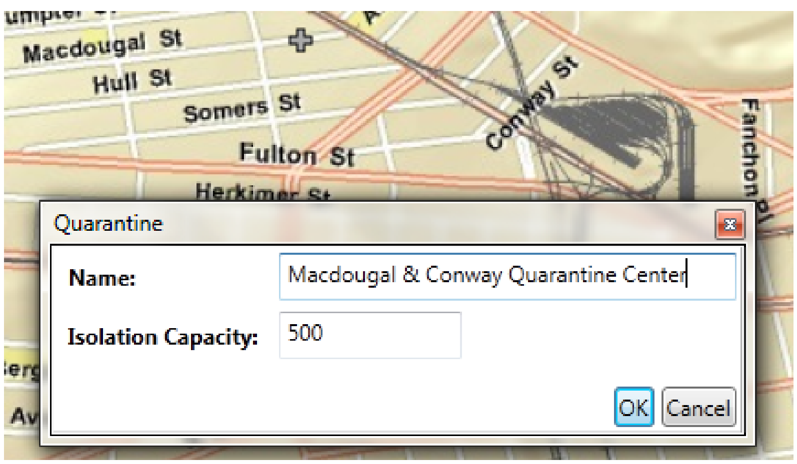

Figure 3-12. Quarantine center placement in DRACCM.

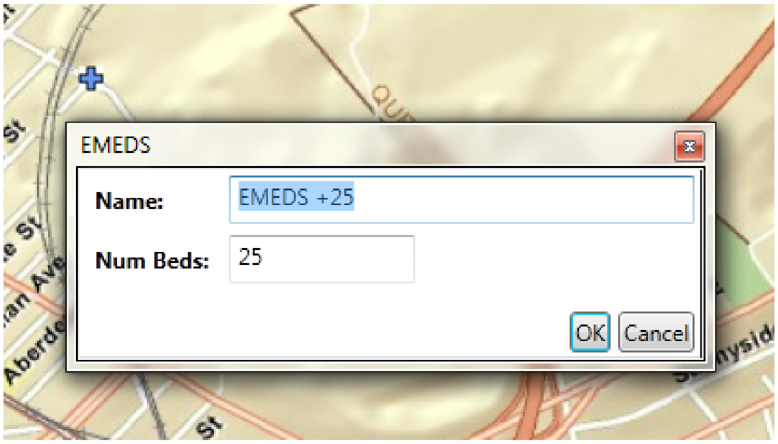

Figure 3-13. EMED +25 placement in DRACCM.

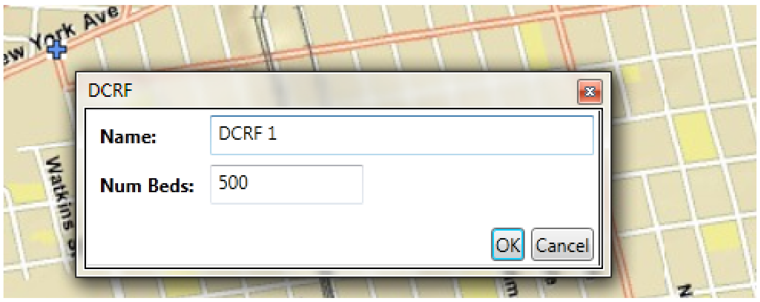

Figure 3-14. DCRF placement in DRACCM.

The quarantine unit illustrated in Figure 3-12 is used for contagious diseases and allows planners to sequester a portion of the exposed and infectious population so that they cannot communicate infection to the susceptible population. The user specifies the isolation capacity of the unit and the contagious disease model will route people to the unit accordingly.

The EMEDS and DCRF units have pre-defined resources associated with them (beds, personnel, materiel, etc.). The user can scale these values up or down by changing the number of beds associated with the unit. The user can also specify when these packages come into the scenario in order to study whether or not the package could realistically get to the incident site quick enough to do any good.

In addition to the packages shown above, DRACCM can also phase in resources from the Strategic National Stockpile (including vaccinations and prophylaxis resources for contagious diseases), Navy Hospital Ships, Combat Support Hospitals, and a large selection of military hospitals and treatment centers.

4.0 DRACCM SAMPLE ANALYSIS

In this sample analysis we will look at the ability of the local medical infrastructure to successfully handle chemical, biological and radiological incidents in a standard scenario and how the DoD would best be able to augment the civilian medical system.

The benefits of using DRACCM for this scenario are:

- Local hospital data integrated into program; FEMA HAZUS database + American Hospital Association data
- State, Federal, & DoD Resources can be phased in via DRACCM
- Injury and countermeasure effectiveness models have been transitioned from the DTRA medical countermeasure modeling program

The injury and countermeasure models in DRACCM are summarized below. They are described in detail in their corresponding reference documents.

- Anthrax (Byers, 2011): Uses Allied Medical Publication 8 (AMedP-8) injury models w/evidence-based countermeasure models
  - Includes incomplete vaccinations, late-administered PEP, and other resource-limited care/non-compliance situations
- Sarin (Rodriguez & McClellan, 2011): Correlates attack rate at nerve synapses with published toxicity data; countermeasures modeled at molecular level
  - Includes exposure-dependent time-course of illness and countermeasure efficacy for delayed treatments
- Cesium (Stricklin & Millage, 2011): Biokinetic model tracks cesium distribution in the body and Prussian Blue efficacy at the removal site (small intestines)
  - Includes whole-body dose and countermeasure efficacy for delayed or incomplete treatments

4.1 SCENARIO SPECIFICATIONS

<u>Scenario</u>: 50,000 people targeted at a stadium + surrounding community. Examine separate *Bacillus anthracis* (anthrax), sarin and cesium releases.

Releases are calculated in JEM and imported into DRACCM as shown in Figure 4-1. Individuals within the stadium (custom population, red square) and the outlying populations are exposed to the releases. DRACCM calculates the number of casualties and fatalities expected from a release with no treatment as well as the critical resources that would be required to treatment the injured and ill. Figure 4-2 shows sample output from DRACCM: (left-hand side) a casualty table with a distribution of seek treatment times and (right-hand side) the number of doctors that would be needed each day to treat the sick.

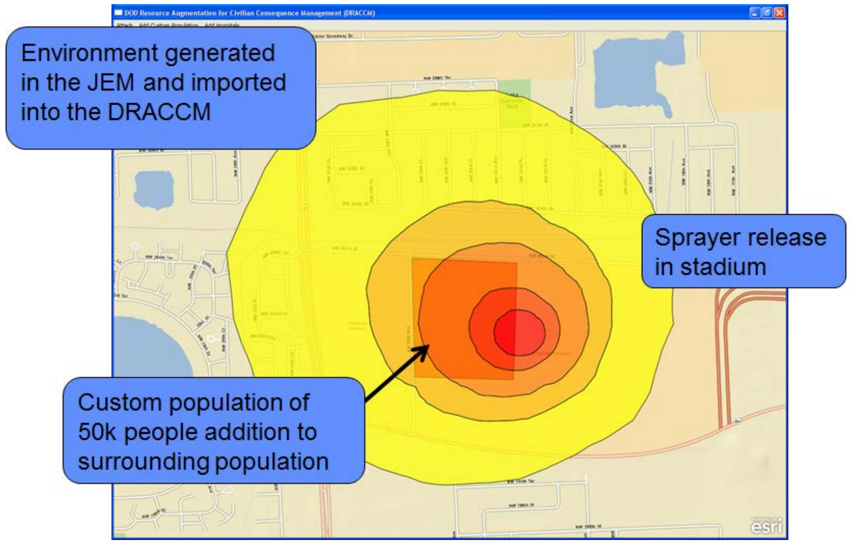

Figure 4-1. JEM release imported into DRACCM

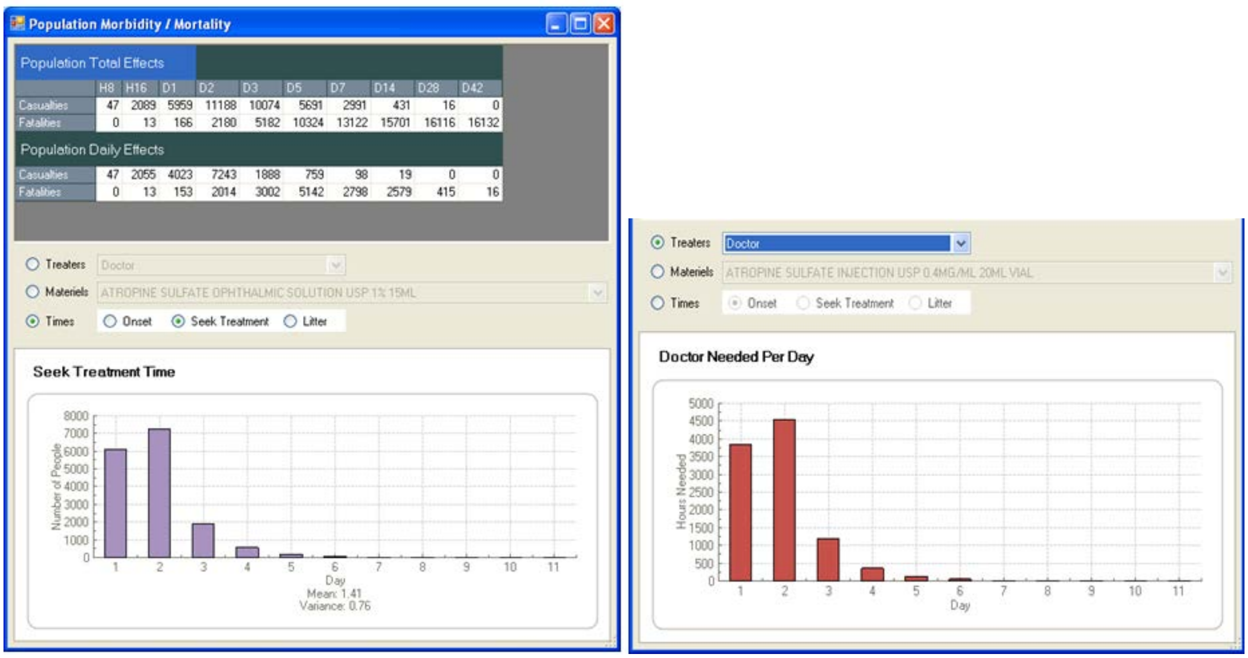

Figure 4-2. Sample outputs in DRACCM; seek treatment time (left) and doctors needed per day (right)

DRACCM gives planners the ability to look at multiple resource requirements for a given incident but in this analysis, f*or illustration purposes only*, we assumed:

- Anthrax Scenario: No pre-exposure vaccination; post-exposure prophylaxis is the critical need

- Sarin Scenario: No pre-exposure bioscavengers; oximes (nerve agent antidote) is the critical need
- Cesium Scenario: Prussian Blue is the critical need for cesium decorporation

In all scenarios we also looked at the bed requirements as a function of time.

The first step in the analysis is to assess resource shortfalls and phase in assets as needed to address the shortfalls. For all of these scenarios, the resources we marked as critical were not available at the hospitals to treat individuals so additional resources had to be brought in. Figure 4-3 illustrates this process where the closest civilian hospital is red (meaning a critical resource has been over-allocated), ciprofloxacin and vaccines have been phased in from the Strategic National Stockpile starting at 18 hours and 32 hours, respectively, and two EMEDS were phased in at 60 and 72 hours and a DCRF was phased in at 48 hours.

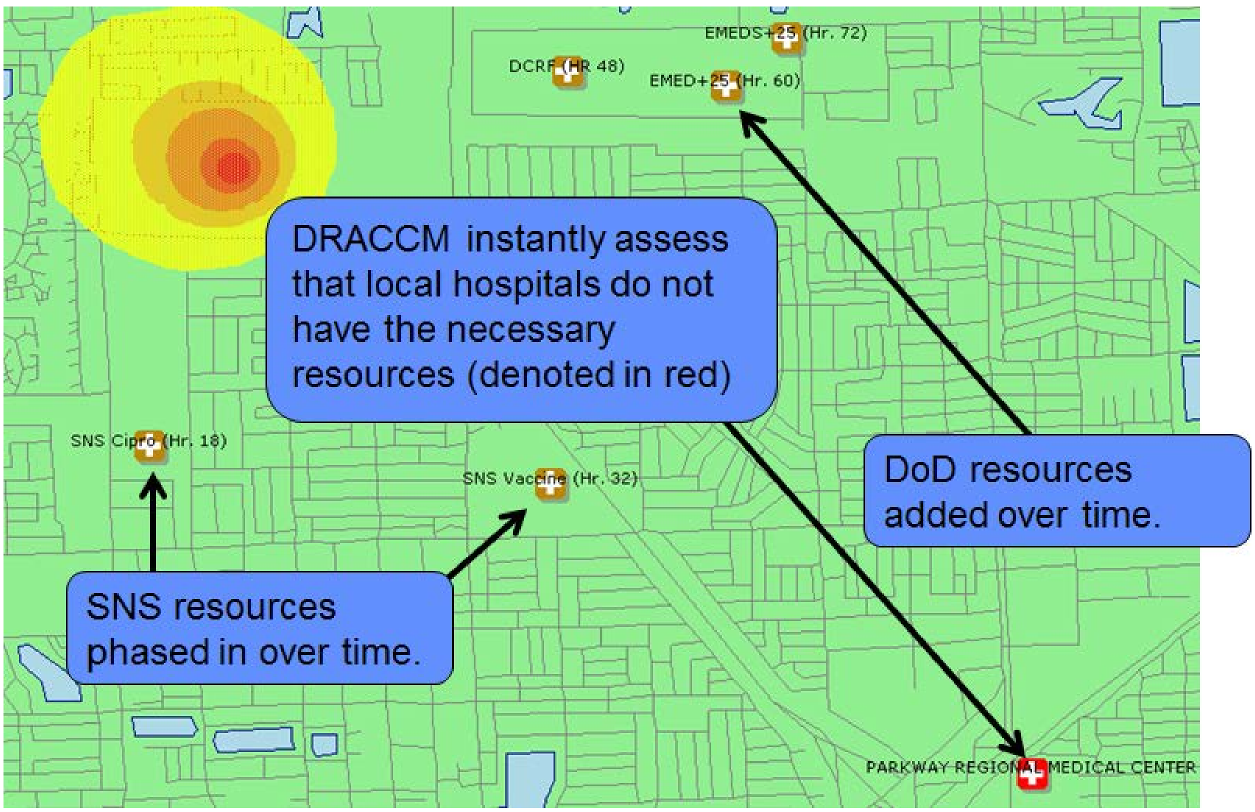

Figure 4-3. Phasing in augmentation packages in DRACCM.

DRACCM then provides a quantitative analysis of this course of action. Results for the three incidents are presented in the next subsections.

4.2 ANTHRAX

For anthrax, we looked at three possible augmentation scenarios:

- No augmentation; local hospitals are left on their own
- Significant influx of post-exposure prophylaxis, beds, and hospitals by Day 3 (a likely scenario)
- Significant influx of post-exposure prophylaxis, beds, and hospitals by Day 1 (a highly unlikely scenario)

The results of the analysis are shown in Figure 4-4. The number of ill people in the first scenario (no augmentation; blue; solid line) is 24,900. The number of ill people in the second scenario (augmentation on Day 3; dashed line) is approximately 7,000. The number of ill people in the third scenario (augmentation on Day 1) is not shown as the models predict that there would be no anthrax illnesses with such an aggressive response.

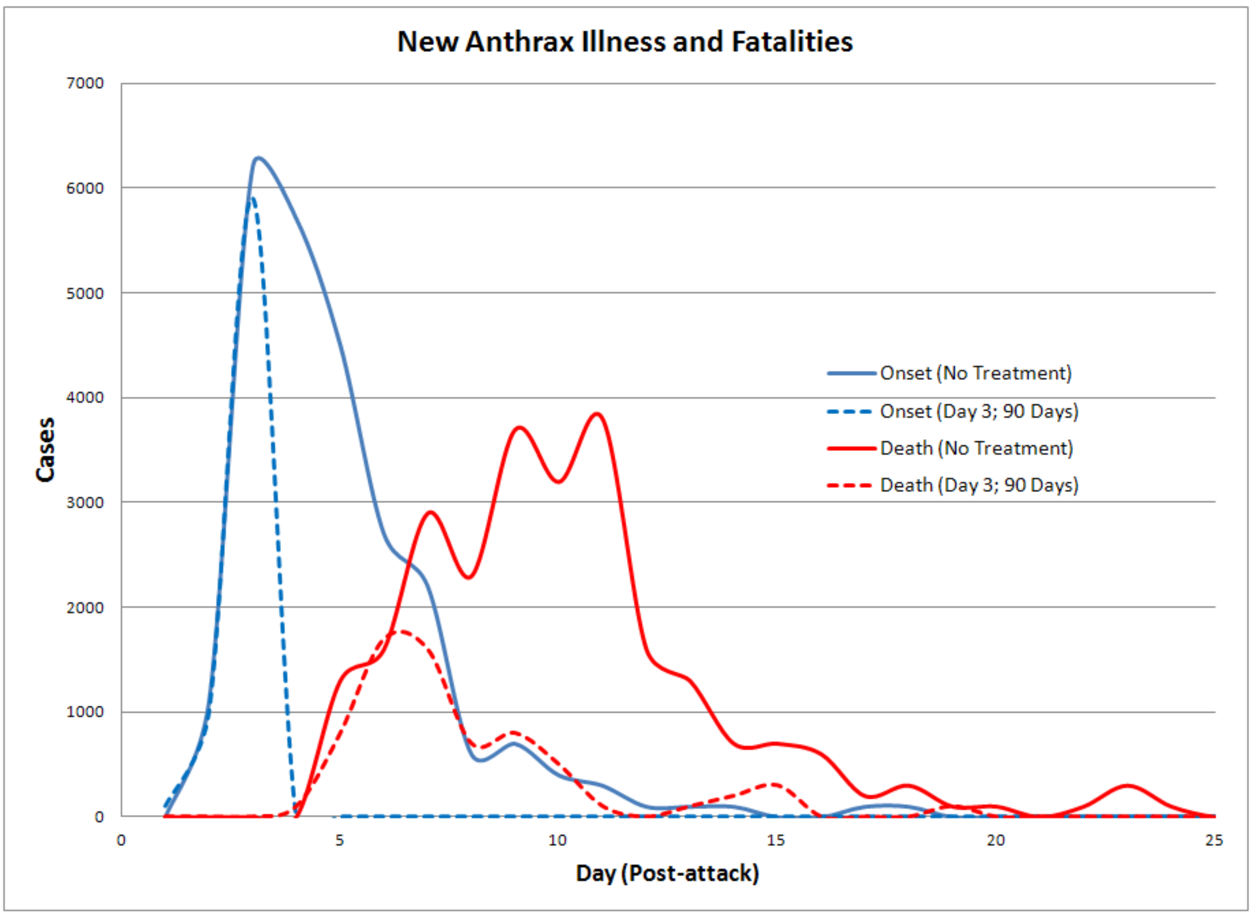

Figure 4-4. Anthrax illness and fatalities for three different augmentations

But this analysis is looking so far only at the effects of prophylaxis and assumes that there are enough beds and doctors to treat people. Figure 4-5 shows the bed requirements to carry out the

no augmentation (solid blue) and Day 3 augmentation (dashed line) scenarios. The red line indicates the number of available beds. As you can see, there is still a 4,000 bed shortfall in the Day 3 augmentation scenario, which is better than the 13,000 bed shortfall in the no-augmentation scenario but still a critical gap. A DoD planner would need to either aid in getting prophylaxis into theater quicker or be prepared to aid in setting up massive temporary treatment facilities in a short amount of time.

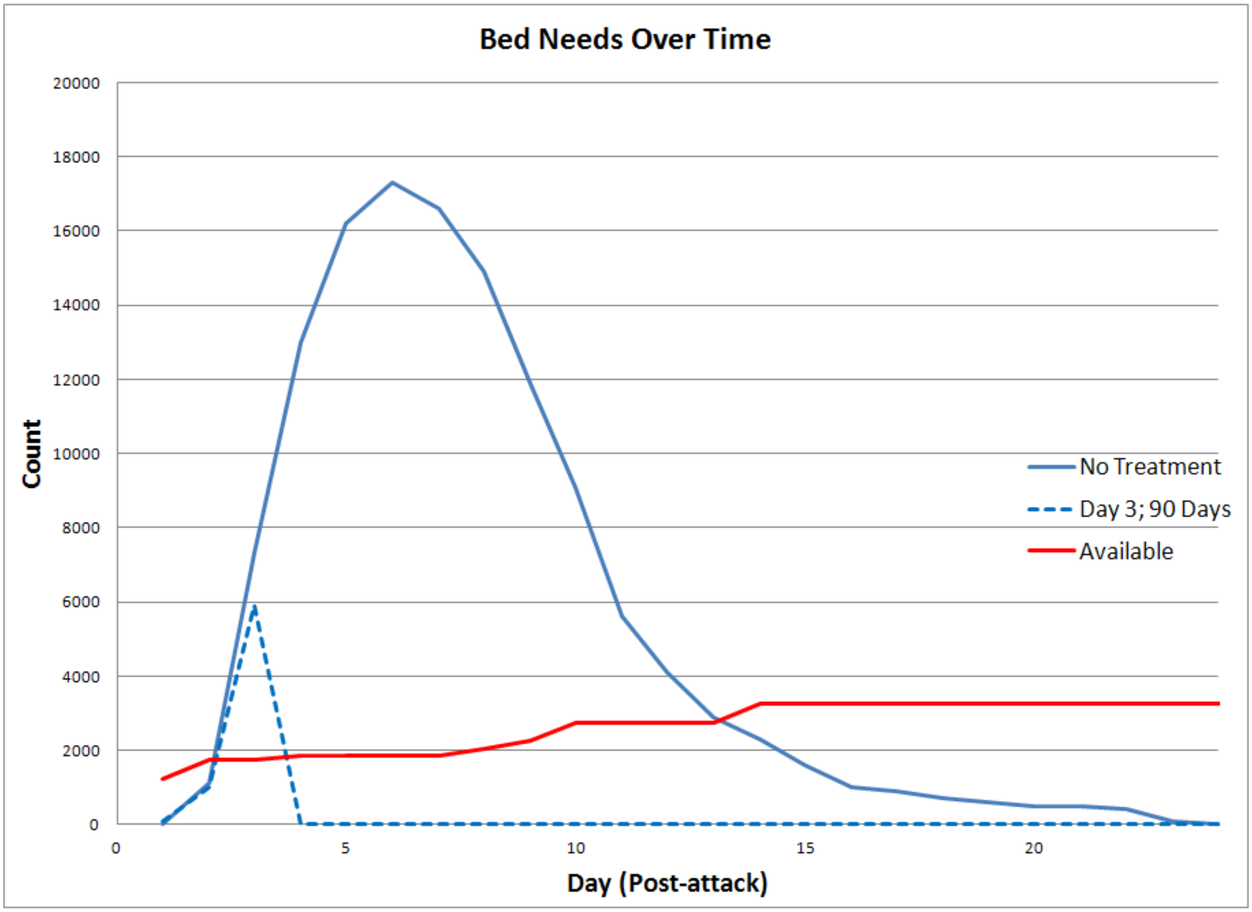

Figure 4-5. Bed needs over time for anthrax incident.

4.3 SARIN

Figure 4-6 shows the distribution of population by probability of mortality for three different sarin scenarios: one where there is no medical augmentation (blue line), a difficult augmentation plan for which oximes arrive within 12 hours (green dotted line), and an almost impossible scenario where oximes arrive within 1 hour (red line). The scenario for which oximes arrive in 12 hours essentially overlays the no-augmentation scenario and so results in virtually no change from the scenario where there is no augmentation. In fact, of the 58,642 people in this scenario

that are expected to have some level of illness, 5,454 are expected to die in the scenario where there is no medical augmentation and 5,450 people are expected to die in the scenario where augmentation arrives at 12 hours. If oximes can be employed within 1 hour, the number of fatalities drops to 2,662 – still a significant number for such an aggressive response plan.

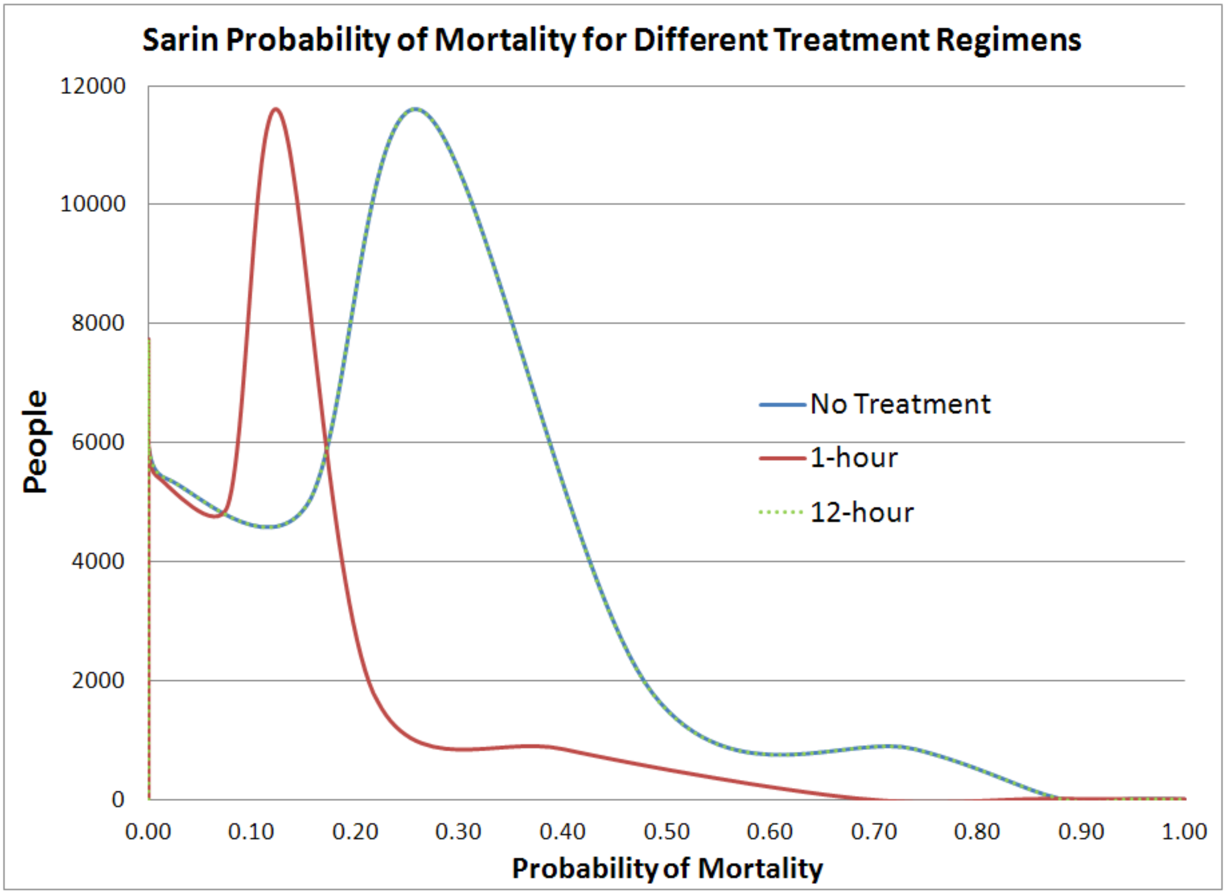

Figure 4-6. Oxime treatment of sarin exposure at 1 hour post-exposure reduces fatalities but not at 12 hours.

Bed requirements shown in Figure 4-7 for the sarin incident for the three augmentations indicate that that the situation is much worse than just the number of fatalities. The bed requirements (over 50,000 for the early days of the scenario) are not even close to being met by the combination of local hospitals and DoD augmentation. And in this case, unlike in the anthrax case, the more aggressive medical augmentation plan (Hour 1 for oximes), results in the need for over 2,000 additional beds as there are now over 2,000 people who would have died but, instead, have moderate-to-severe organophosphate poisoning. The good news is that the augmentation plan does allow for the long-term treatment of individuals who have severe poisonings as shown in Figure 4-7. It would be up to the planners to decide how to properly triage ill people so that the more severe casualties get bed priority whereas individuals with mild symptoms (tremors, etc.) could be treated as outpatients.

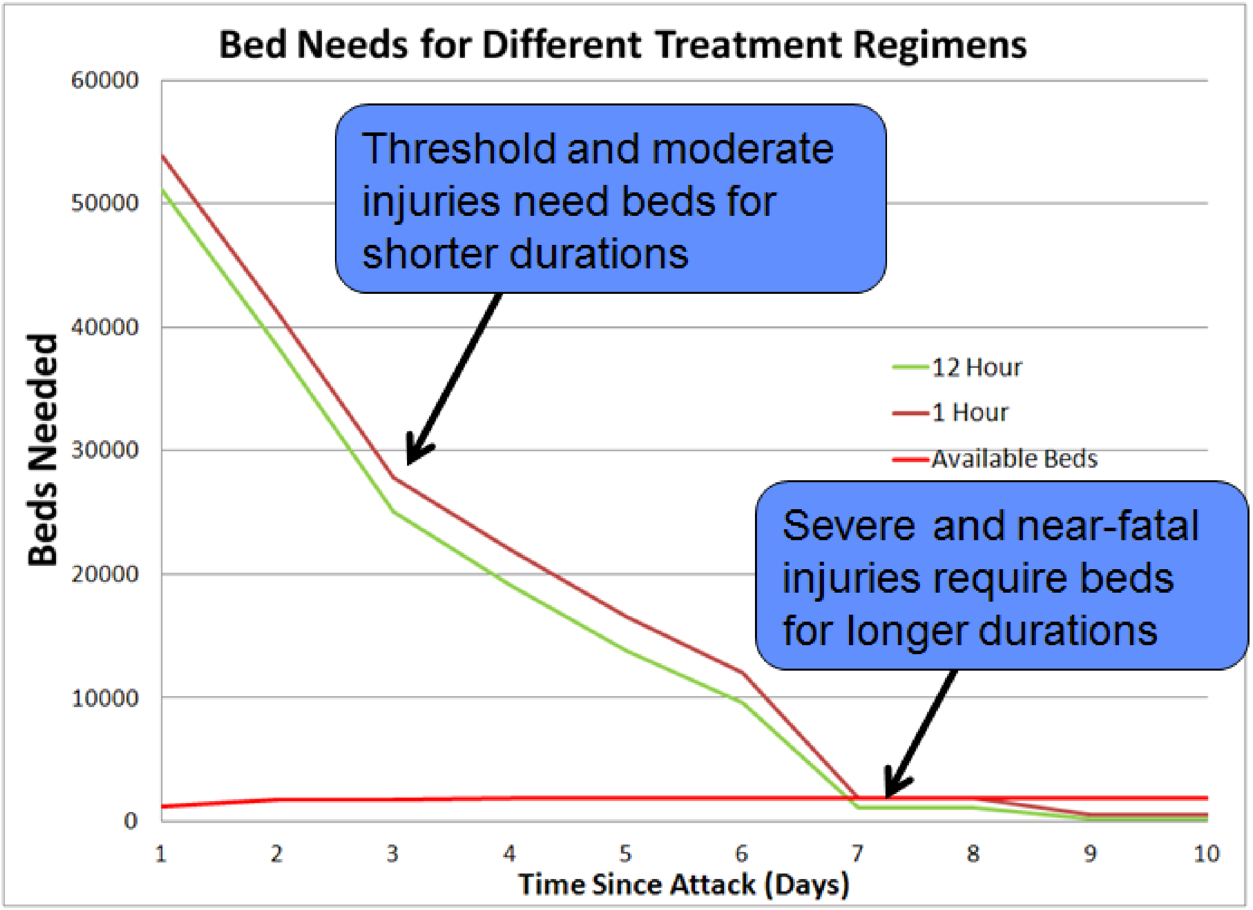

Figure 4-7. Bed needs for sarin incident.

4.4 CESIUM

In the cesium incident, no one received an acute dosage high enough to warrant immediate hospitalization, so beds were not a priority. Prussian Blue, however, is a priority to limit long-term health risks. We analyzed five treatment actions in DRACCM: 1) no augmentation, 2) 30 days of Prussian Blue for each exposed individual starting at Hour 12, 3) 30 days of Prussian Blue for each exposed individual starting at Day 3, 4) 90 days of Prussian Blue for each exposed individual starting at Hour 12, 5) 90 days of Prussian Blue for each exposed individual starting at Day 3. Figure 4-8 shows some interesting results.

Firstly, the no treatment (augmentation) scenario results in the highest distribution of internalized doses across the population and the most aggressive scenario (90 days of treatment starting at Hour 12) results in the greatest reduction of population dose and, therefore, long-term health risks. However, the analysis also shows that there is little difference between 30 days of treatment starting at Hour 12 and 90 days of treatment starting at Day 3, so time and resources could be preserved by getting a smaller amount of materiel into the incident site more quickly.

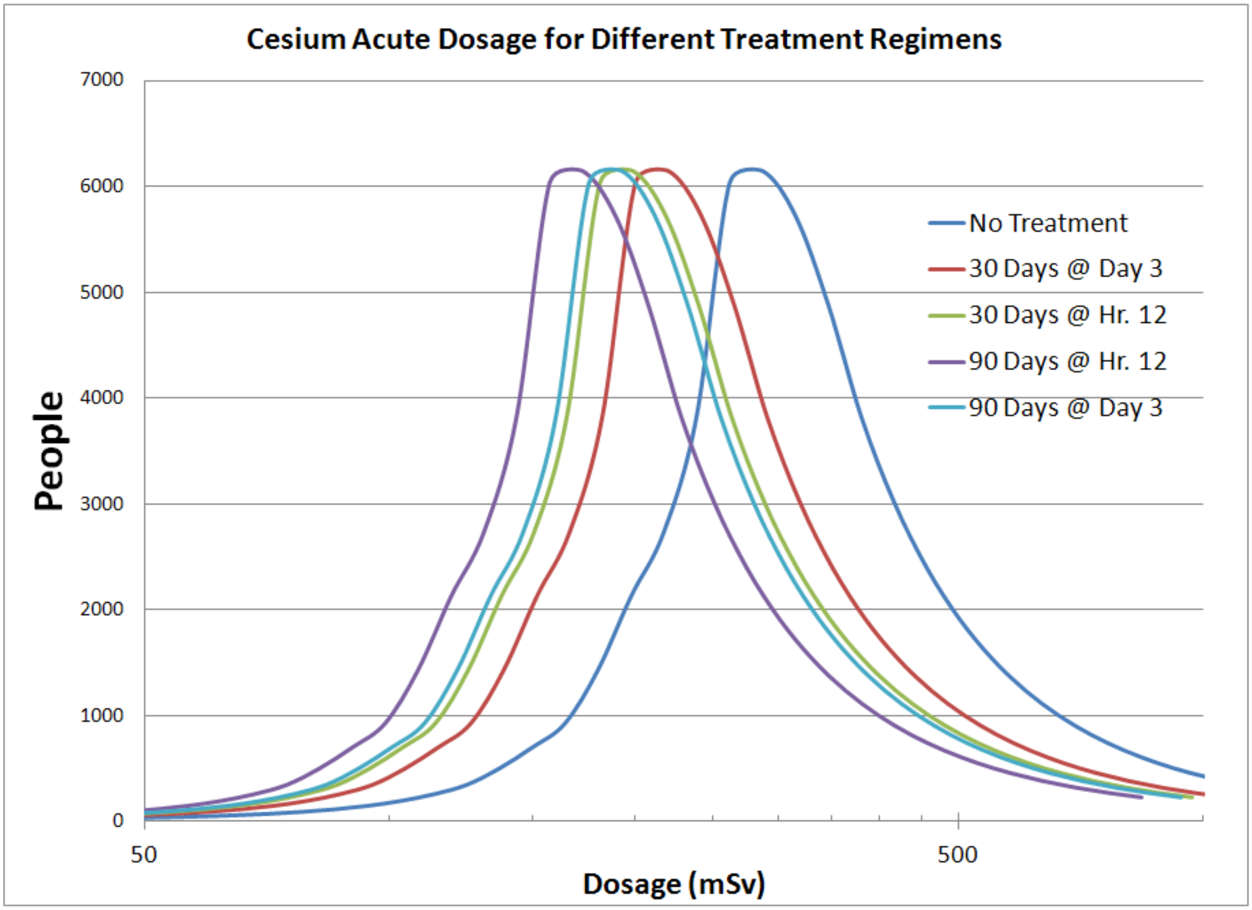

Figure 4-8. Cesium Acute Dosage distribution for five augmentations.

4.5 SUMMARY

By leveraging DRACCM's ability to model the effects of resource-limited care, planners can better understand the role that DoD should play in response. For this example scenario with three incidents, we make the following observations:

- Anthrax incident: Beds (and doctors) would be needed in 3-5 days with post-exposure prophylaxis taking an immediate precedent; DoD could aid with beds, doctors, and medication distribution
- Sarin incident: Beds, doctors, and material would be needed within minutes to hours; DoD could not currently fulfill these requirements but could aid with beds
- Cesium incident: Beds and doctors would not be immediately necessary; DoD could help with medication distribution

Additionally, accounting for the effects of resource-limited care informs where critical resources should reside for effective employment, something DRACCM can aid planners with as well.

5.0 CONCLUSIONS

DRACCM is a powerful tool for estimating resource requirements for a civilian population. Its foundation is a streamlined, user-intuitive interface. It uses real hospital data and high-fidelity models of illness and disease transmission. It is easily expandable to include new threats, resource models, and augmentation packages and can aid medical planners in understanding the distribution requirements for critical resources following a CBRN incident.

Future development should include OCONUS support, additional augmentation packages, more detailed population builders and demographic models, and user testing and feedback.

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7.0 DEFINITIONS, ACRONYMS, AND ABBREVIATIONS

AMedP-8(B)	Allied Medical Publication 8, Version B
ANG	Alabama National Guard
APL	Applied Physics Lab
ARA	Applied Research Associates, Inc
CBR	Chemical, Biological and Radiological
CBRN	Chemical, Biological, Radiological and Nuclear
CDC	Center for Disease Control
CNIMS	Comprehensive National Incident Management System
CONUS	Continental United States
CREST	Casualty & Resource Estimation Support Tool
DCRF	Defense CBRN Response Force
DoD	Department of Defense
DRACCM	DoD Resource Augmentation for Civilian Consequence Management
DTRA	Defense Threat Reduction Agency
ESRI	Environmental Systems Research Institute, Inc.
EMEDS	Expeditionary Medical Support
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
GUI	Graphical User Interface
HAZUS	Hazardous United Status
H1N1	Avian Influenza
HPAC	Hazard Prediction & Assessment Capability
IDAC	Infectious Disease Analysis Capability
IV&V	Independently Verified & Validated
JEM	Joint Effects Model
JHU	John Hopkins University
JTF	Joint Task Force
NBC CREST	Nuclear, Biological and Chemical (NBC) Casualty & Resource Estimation Support Tool
NORTHCOM	Northern Command
OCONUS	Outside Continental United States
SEB	Staphylococcal Enterotoxin B
SEIR	Susceptible, Exposed, Infected or Removed
TIC	Toxic Industrial Chemical
VEE	Venezuelan Equine Encephalitis
VX	An organophosphate nerve agent

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